

### **REMARKS**

Claims 1 and 3-10 are pending in the present application. Applicants respectfully request reconsideration of this application in view of the amendments and remarks herein.

Claims 1 and 8 have each been amended to limit the suitable zeolites to those having a ratio of Si:Al equal to 15 or greater. Basis is in the specification at page 3, lines 21-25; page 7, lines 25-26; page 12, line 25 to page 13, line 6; page 13, lines 7-21; and in original claim 9. Claim 7 was amended to recite silica as a sorbent. Basis is in the specification at page 2, lines 25-35; page 7, lines 21-25. Claims 7 and 9 were each amended to recite that it is the zeolite which has the recited Si:Al ratio. Basis is in the specification at page 2, lines 25-34; and page 7, lines 25-26.

#### **I. Rejection under 35 USC 112**

Claims 1, 3-6, 8 and 10 were rejected under 35 USC 112, first paragraph, for lack of enabling disclosure. Claims 7 and 9 were rejected under 35 USC 112 second paragraph as indefinite. Applicants respectfully traverse these rejections.

Applicants' cited basis for the ratio of "greater than or equal to about 15" was stated to provide basis only for a ratio equal to 15, and it was stated that there was no descriptive support in the specification for employing a zeolite having a silicon to aluminum ratio of greater than about 15. Applicants respectfully maintain that the specification does support zeolites having a Si:Al ratio which is higher than 15. At page 3, lines 21-25 it is stated that the ratio can be about 5.1 **or greater**. Again the specification at page 7, lines 21-26, teaches that any ratio greater than 5.1 is suitable for use in the presently claimed invention. The description states that preferred are ratios of at least 25. Applicant has clearly provided examples wherein the ratio is higher than 15. See Example 7 at page 12, line 25 to page 8, line 6 for a ratio of 55. See also Example 8 at

page 13, lines 8-21 for a ratio of 45. Applicants therefore maintain that descriptive support for ratios higher than 15 clearly exists in the application, and that such ratios are enabled by the specification. Applicants respectfully submit that claims 1, 3-6, 8 and 10, as amended herein, are in compliance with the requirements of 35 USC 112, first paragraph.

Claims 7 and 9 were stated to be indefinite in use of the term "silicalite" and that it had no antecedent basis. It was further stated that it was unclear if the recited ratio applied to both the silica and zeolite. In response Applicants have amended claim 7 to recite silica instead of silicalite to advance prosecution. Silicalite is a form of silica as a powder available from Union Carbide, Moorestown, NJ and was employed in Applicants' Examples 4 and 5 at page 11 in the specification. Enclosed is a description of silicalite S-115 from Union Carbide describing it as having a structure composed entirely of silica. Both claims 7 and 9 were amended to clarify that the recited ratio is applicable only to the zeolite. In view of these amendments, Applicants submit that claims 7 and 9 are not vague, and do particularly point out and distinctly claim the subject matter of the invention in compliance with 35 USC 112, second paragraph.

## II. Rejection under 35 USC 103

Claims 1 and 3-6 and 8-10 were rejected under 35 USC 103 as unpatentable over Amelin et al., Russian Invention Specification 226567, in view of either US Patent 5,647,903 of McGill et al. or US Patent 6,168,773 of Sharp. Applicants respectfully traverse this rejection.

The Amelin et al. patent was cited as teaching absorption of sulfur trioxide produced from gaseous mixtures onto silica gel, with subsequent desorption, and that the dry solid product was transportable. Sharp and McGill et al, were cited as teaching silica having a pore size in Applicants' claimed size range. Thus it was considered obvious to employ silica having the pore size taught in Sharp and McGill et al. in the Amelin et al. process.

Applicants' invention is directed to reversible sorption of sulfur trioxide while maintaining high activity of the sorbent upon recycle. The ability to recycle the sorbent is clearly required in Applicants' claim 1, substep c. To obtain continued high activity upon recycle or reuse of the sorbent requires avoiding structural degradation of the sorbent. Structural degradation of the sorbent results in a loss of sorption capacity for sulfur trioxide thus preventing or limiting recycle. When there is a need for use of small volumes of sulfur trioxide, small containers of SO<sub>3</sub>-loaded sorbent can be obtained from a site equipped to handle the hazards presented by bulk storage of sulfur trioxide, the sulfur trioxide desorbed from the SO<sub>3</sub>-loaded sorbent, and the used sorbent sent back for recycle. One requiring small volumes of sulfur trioxide does not have to invest in and manage the hazards of its bulk generation and storage due to the ability to ship and recycle the sorbent.

While Amelin et al. does suggest transport of adsorbed sulfur trioxide, Amelin et al. do not teach or suggest recycling of the sorbent. Thus Amelin et al. do not address the issue of maintaining sorbent activity at a high level upon multiple recycles. Applicants maintain that this silence does not suggest the claimed invention. This silence does not teach anything about recycling of the sorbent.

Since the art teaches a decrease in activity of sorbent upon reuse, there is no reason to expect that Amelin et al's sorbent would behave any differently. As noted by the Examiner, Amelin et al. do not teach or suggest use of a particular pore size for the silica gel employed. Further Amelin et al. do not teach or suggest use of zeolites as sorbents or the particular silicon to aluminum ratio needed. There is no suggestion of how to prevent a decrease in adsorbent activity upon recycling. Amelin et al. simply do not address recycling.

In comparison, Applicants' invention enables numerous recycles by maintaining the stability of the sorbent. Applicants have provided data showing no deterioration of the sorbent molecular structure over ten cycles when the process of the claimed invention is employed.

Amelin et al. also teach absorption of a gas mixture containing 7% sulfur trioxide. Applicants' claims require absorption from a gas containing at least 15% sulfur trioxide. The remainder is preferably an inert gas such as dry nitrogen. See page 4, lines 21-25 of the specification. Preferably the sulfur trioxide feed used in Applicant's invention has a sulfur trioxide content equal or greater than 99.5% because the quality of the sulfur trioxide desorbed depends on the quality that was sorbed. See page 8, lines 15-21 of Applicant's specification. Amelin et al. do not specify what is contained in their gas mixture. Thus the majority of the feed stream can be sulfur dioxide or other components that could be detrimental to absorption, purity, or recycle of the sorbent.

Combining Sharp and McGill et al. with Amelin et al. does not suggest Applicants' invention. Although Sharp and McGill et al. teach how to prepare silica having various properties including particular pore sizes, there is no suggestion of use of the silica as sorbents for sulfur trioxide, nor of any relationship of pore size to such use. There is no teaching of recycle of silica as a sorbent. Suggested uses in McGill et al. include in paints, as a conditioning agent in foods, and in dentifrices (col. 1, lines 52-58). These are not uses amenable to recycling. Sharp suggests use as a coating on metal or glass (col. 4, lines 36-48), as a separation medium, and for cross-linking in polymers (col. 5, lines 15-30). Thus combining Sharp or McGill et al. with Amelin et al. does not suggest recycle of sorbent, nor what properties are desired to make the sorbents recyclable, nor what properties are required to maintain activity upon recycle. Thus Applicants' invention provides unexpected results not suggested by the cited art. Applicants therefore maintain that Claims 1 and 3-10 are not obvious under 35 USC 103 over Amelin et al., McGill et al., or Sharp, singly or combined.

## II. Conclusions

In view of the amendments and remarks herein, Applicants respectfully maintain that Claims 1 and 3-10 are patentable over the cited art, and respectfully request that a patent be issued on these claims.

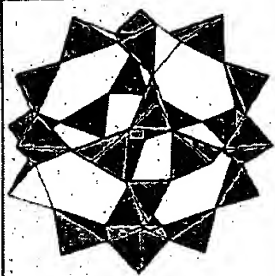
Should any questions arise, the Examiner is invited to contact Applicant's attorney at the number noted below.

Respectfully submitted,



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DATE: March 3, 2004



# Union Carbide Molecular Sieves

developmental products

## S-115

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### DESCRIPTION

Union Carbide S-115 silicalite is a new, novel, crystalline, silica material which exhibits characteristics of molecular sieves. S-115 silicalite does not have ion-exchange properties similar to aluminosilicate zeolites because its structure is composed entirely of silica. S-115 silicalite is a hydrophobic, organophilic material which may find utility in a number of unique applications. It also has excellent steam, thermal and acid stability.

The crystal structure of S-115 silicalite is a new topologic type of tetrahedral framework, which contains a large fraction of five-membered rings of silicon-oxygen tetrahedra. Its channel system is composed of near-circular zig-zag channels (free cross-section  $5.4 \pm 0.2 \text{ \AA}$ ) cross-linked by elliptical straight channels with a free cross-section of  $5.75 \times 5.15 \text{ \AA}$ . Both channels are defined by 10-rings.

At ambient temperature S-115 silicalite will adsorb molecules as large as benzene (kinetic diameter  $5.85 \text{ \AA}$ ), but rejects molecules larger than  $6 \text{ \AA}$  (e.g., neopentane— $6.2 \text{ \AA}$ ). Although the pore size effect

can be used in molecular sieving, the most remarkable adsorption property of S-115 silicalite is its surface selectivity. In contrast to the extremely high preference of aluminosilicate zeolite surfaces for water and other polar molecules, S-115 silicalite has a very low selectivity for the adsorption of water, and a very high preference for the adsorption of organic molecules smaller than its limiting pore size. This property allows S-115 silicalite to perform useful functions in an organic system even in the presence of either liquid or vapor phase water (no water deactivation/poisoning effect).

S-115 silicalite is stable in air to over  $1,000^\circ\text{C}$  and only slowly converts to an amorphous glass at  $1,300^\circ\text{C}$ . The S-115 silicalite molecular sieve is stable to most mineral acids, but reacts with HF in a manner similar to quartz.

In summary, Union Carbide S-115 silicalite is a unique material combining the characteristics of:

- Steam, thermal, and acid stability;
- Molecular Sieve effect; and
- Hydrophobic, organophilic nature.

### CHEMICAL PROPERTIES OF S-115 SILICALITE

>99%  $\text{SiO}_2$

### PHYSICAL PROPERTIES OF S-115 SILICALITE

Free aperture	
Zig-zag channels	$5.4 \text{ \AA}$
Straight channels	$5.75 \times 5.15 \text{ \AA}$
Pore volume	0.19 cc/gm
Crystal density	1.76 gm/cc
Largest molecule adsorbed	Benzene
Form	Powder

### REFERENCES

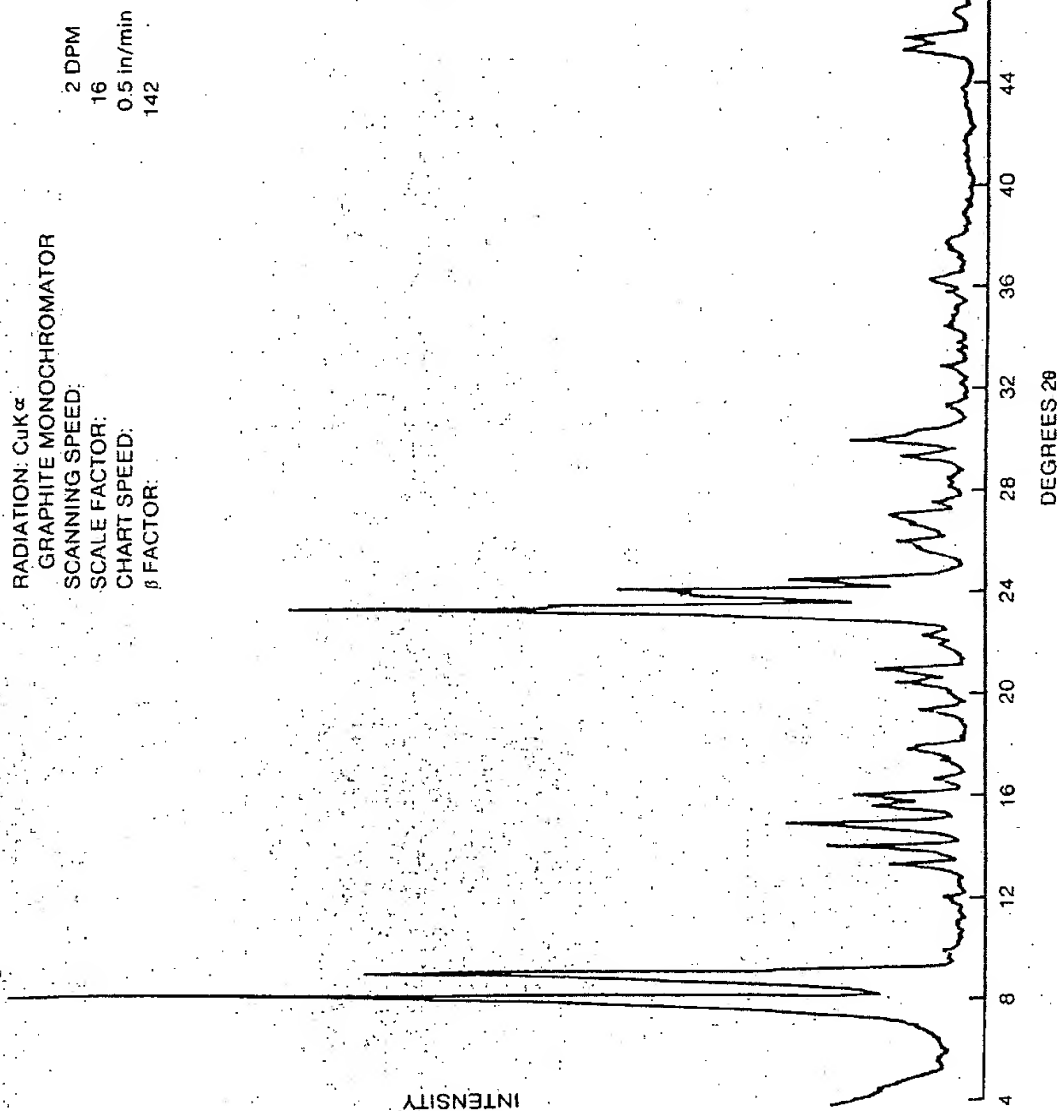
E. M. Flanigen, J. M. Bennett, R. W. Grose, J. P. Cohen, R. L. Patton, R. M. Kirchner, and J. V. Smith, *Nature*, Volume 271, No. 5645, pages 512-516, 1978.

U.S. Patent #4,061,724, R. W. Grose, E. M. Flanigen  
— Union Carbide Corporation, December 6, 1977.



CATALYSTS

# S-115 Silicalite



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## ADDITIONAL INFORMATION

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